

LOOMING WORLD OIL PROBLEMS: MYTHS AND REALITIES

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THIS PRESENTATION

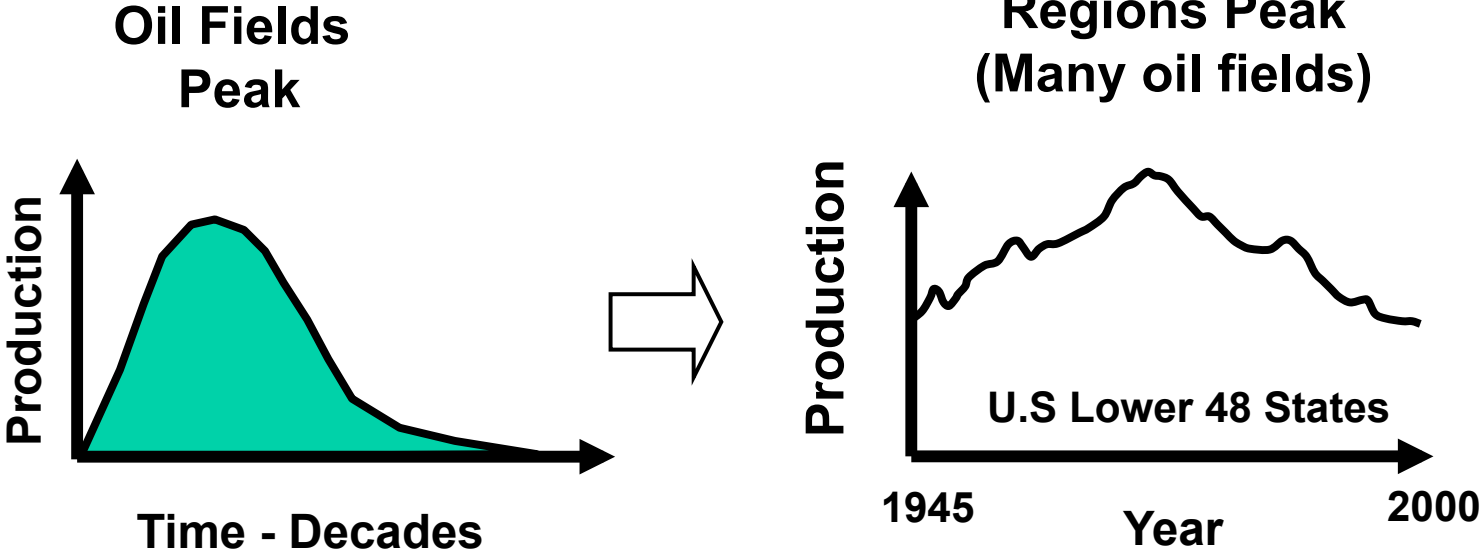
- Nine myths and realities
 1. World is “running out of oil”
 2. Oil shortages wrongly predicted for 100 years – no need to worry now
 3. Higher prices will create more oil
 4. Not to worry, world will muddle through
 5. Just another “energy crisis”
 6. Renewables will save us
 7. Government intervention not required
 8. Plenty of time to address the problem
 9. Oil peaking means “end of civilization as we know it”
- Implications
- Recommendations

Note: **Global warming is currently a major concern. However, peak oil will likely occur suddenly and have severe consequences in the near future.**

1. WORLD IS “RUNNING OUT OF OIL”

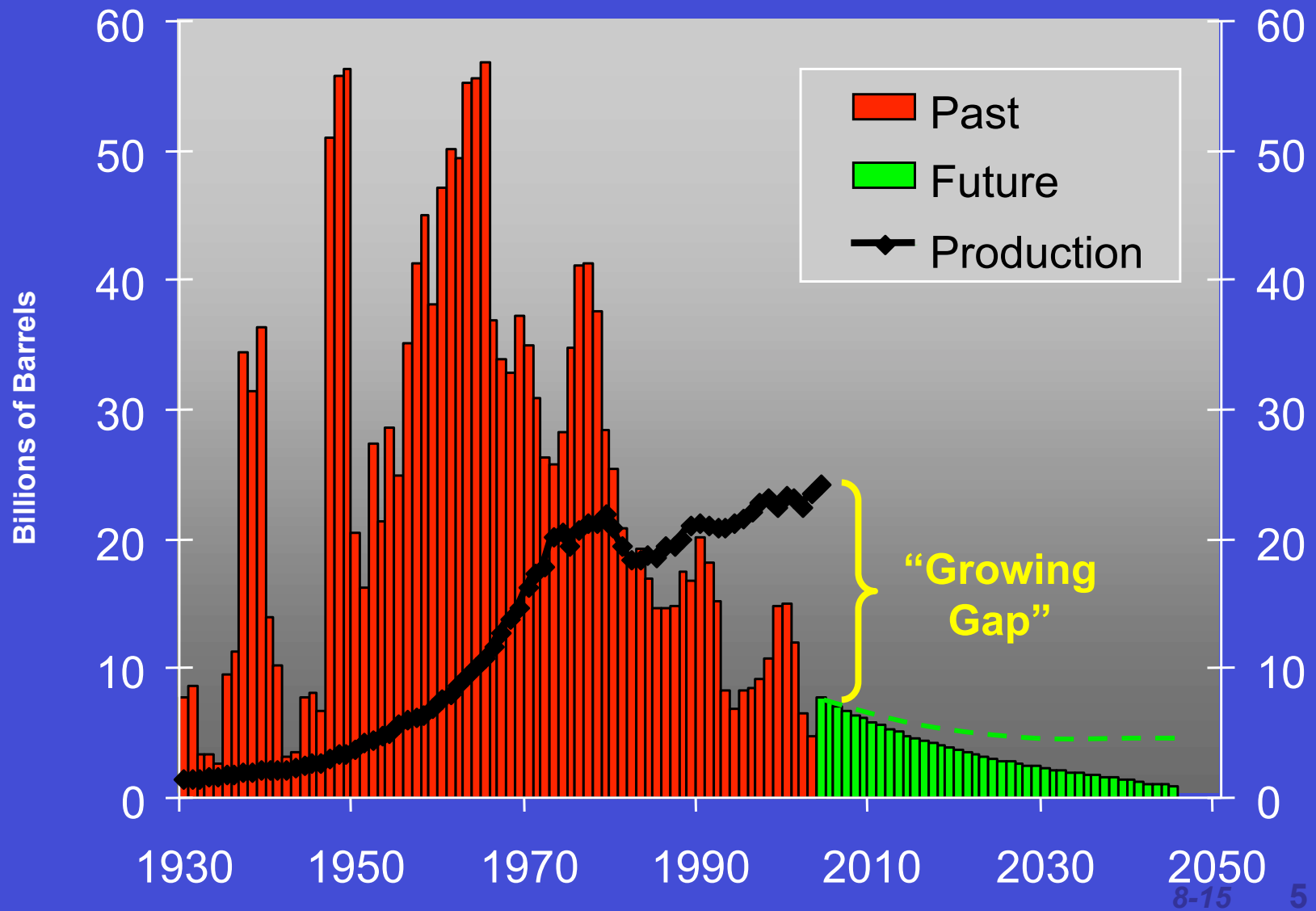
- **In one sense, this is correct**, because oil is a finite resource that we started to deplete when we extracted the first barrel.
- **However, if “running out” is interpreted as the world not having any oil in the near future, we are not.**
- Estimates of remaining oil are in range of 1 – 2 trillion barrels.
- **There will never be a shortage of oil:** At appropriate price supply will always equal demand.
- However, world oil demand is huge & growing.
- Worldwide production of conventional oil (>95% of current use) will not be able to keep up with demand and will peak – reach a maximum and then go into decline.
- This could happen relatively soon, possibly within next decade.
- **Peaking is maximum production of conventional oil, not “running out;” beware of red herrings.**

WHY WILL CONVENTIONAL OIL PRODUCTION PEAK?

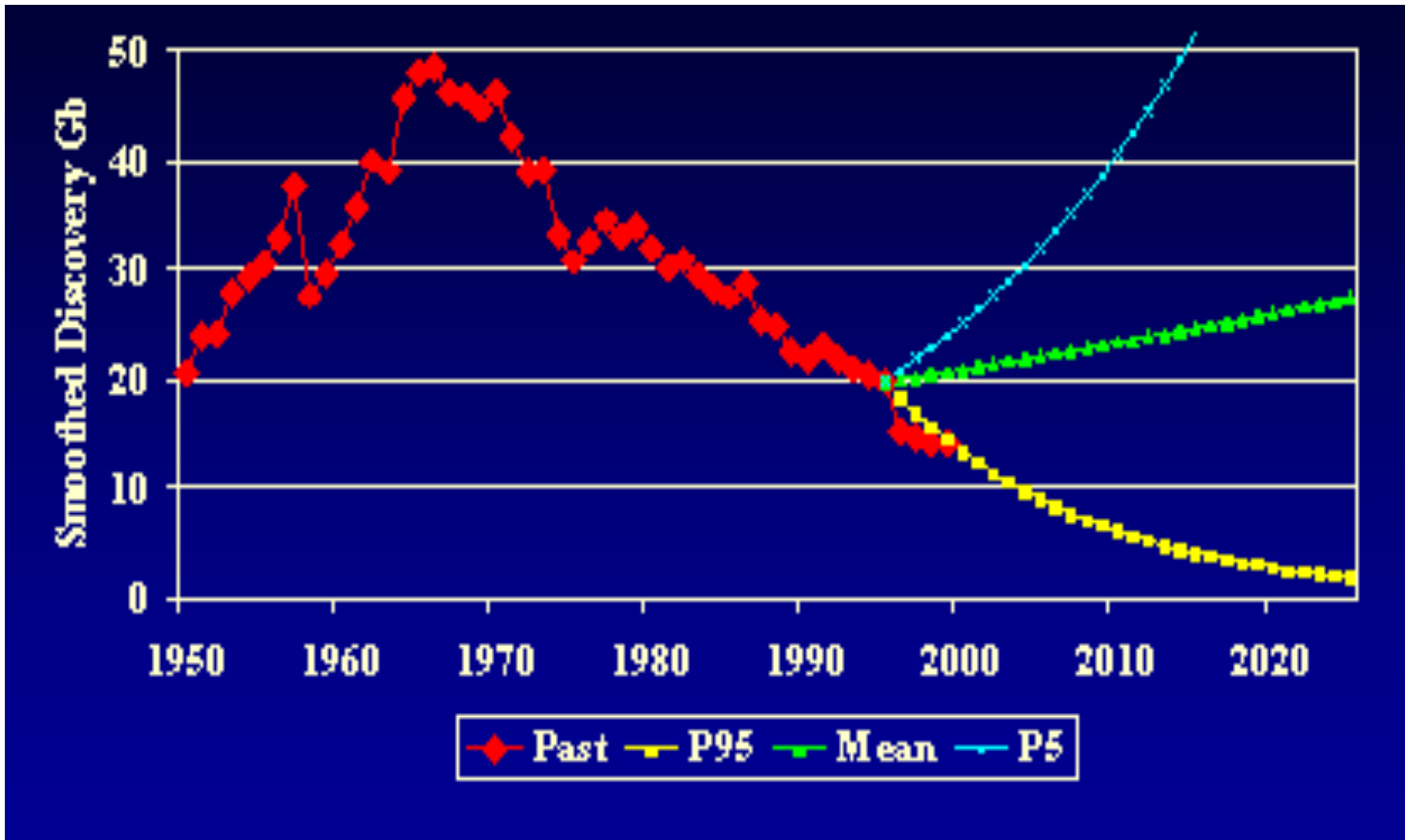


The world will peak
(All regions)

WORLD IS CONSUMING MORE OIL AND FINDING LESS

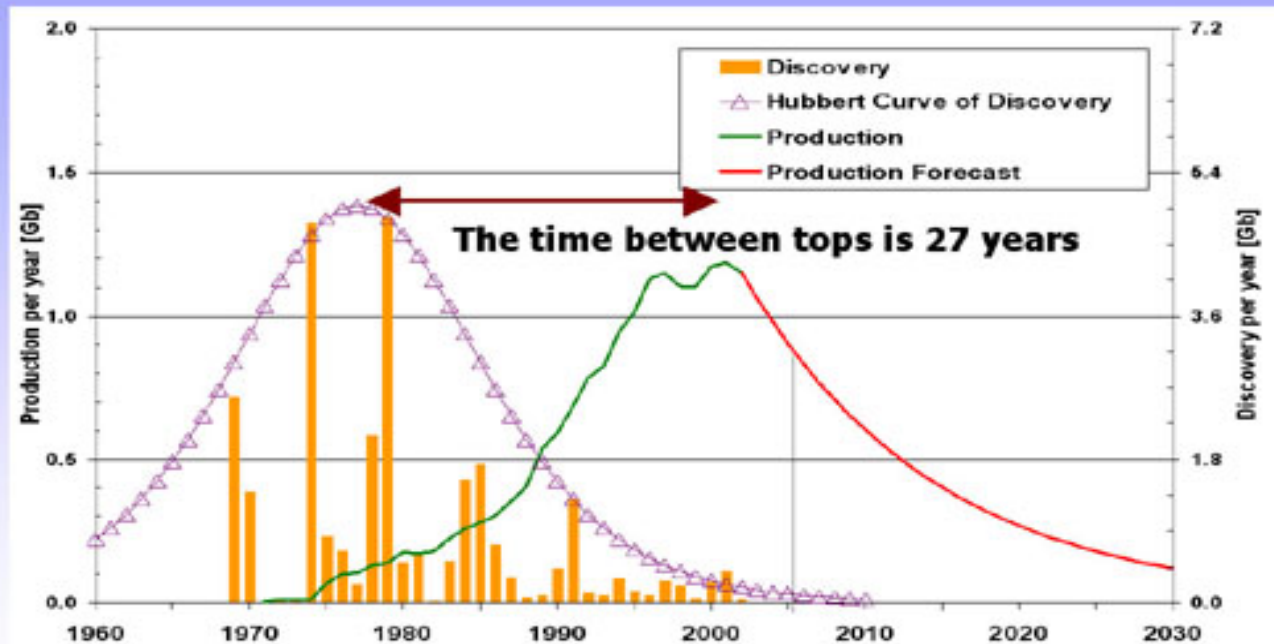


WORLD OIL DISCOVERY HISTORY & THREE PATHS FOR USGS RESERVES ESTIMATES

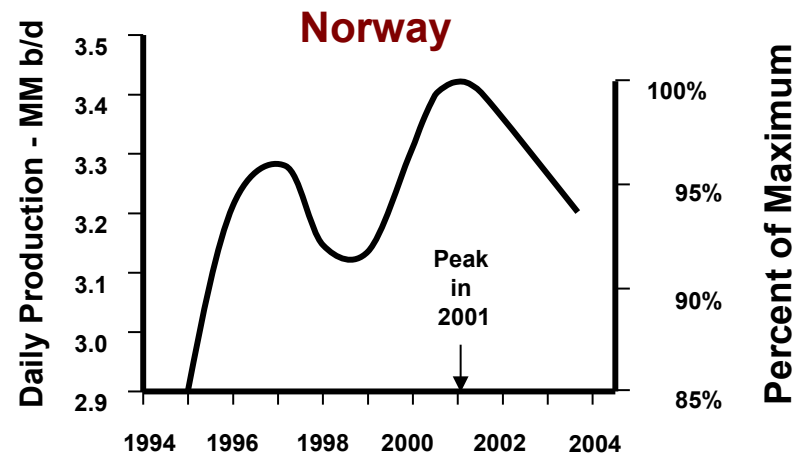
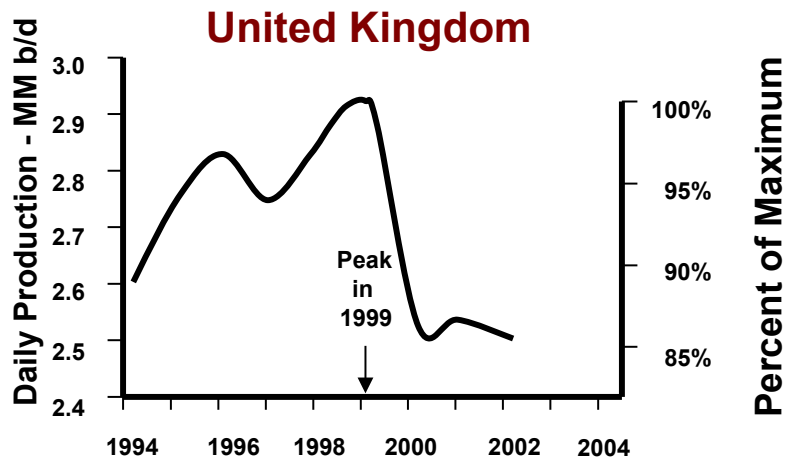
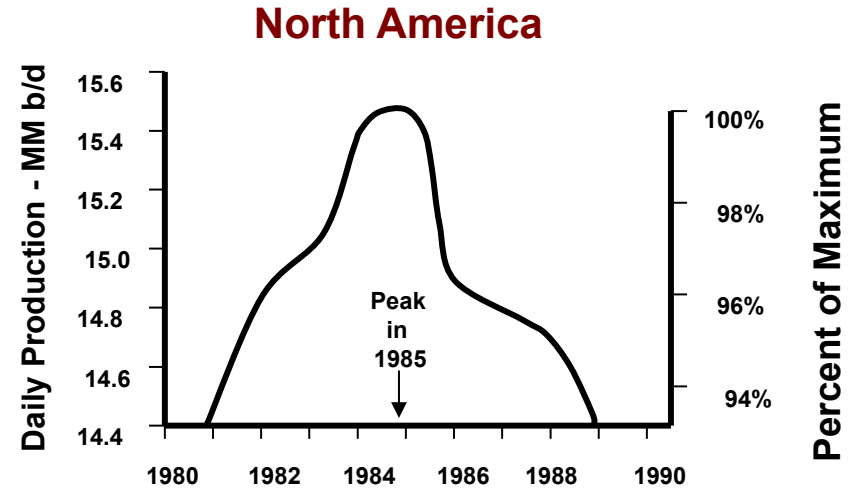
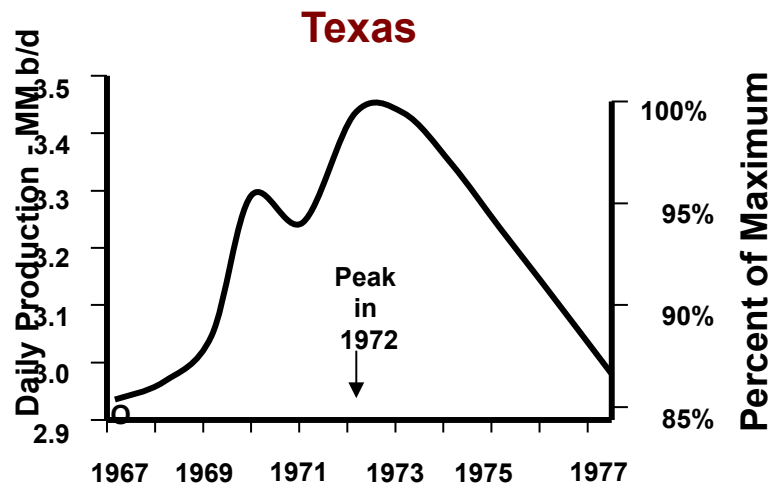


WHEN DISCOVERY DECLINES, PRODUCTION ALWAYS DECLINES LATER -- NORWAY

Found and produced oil in Norway

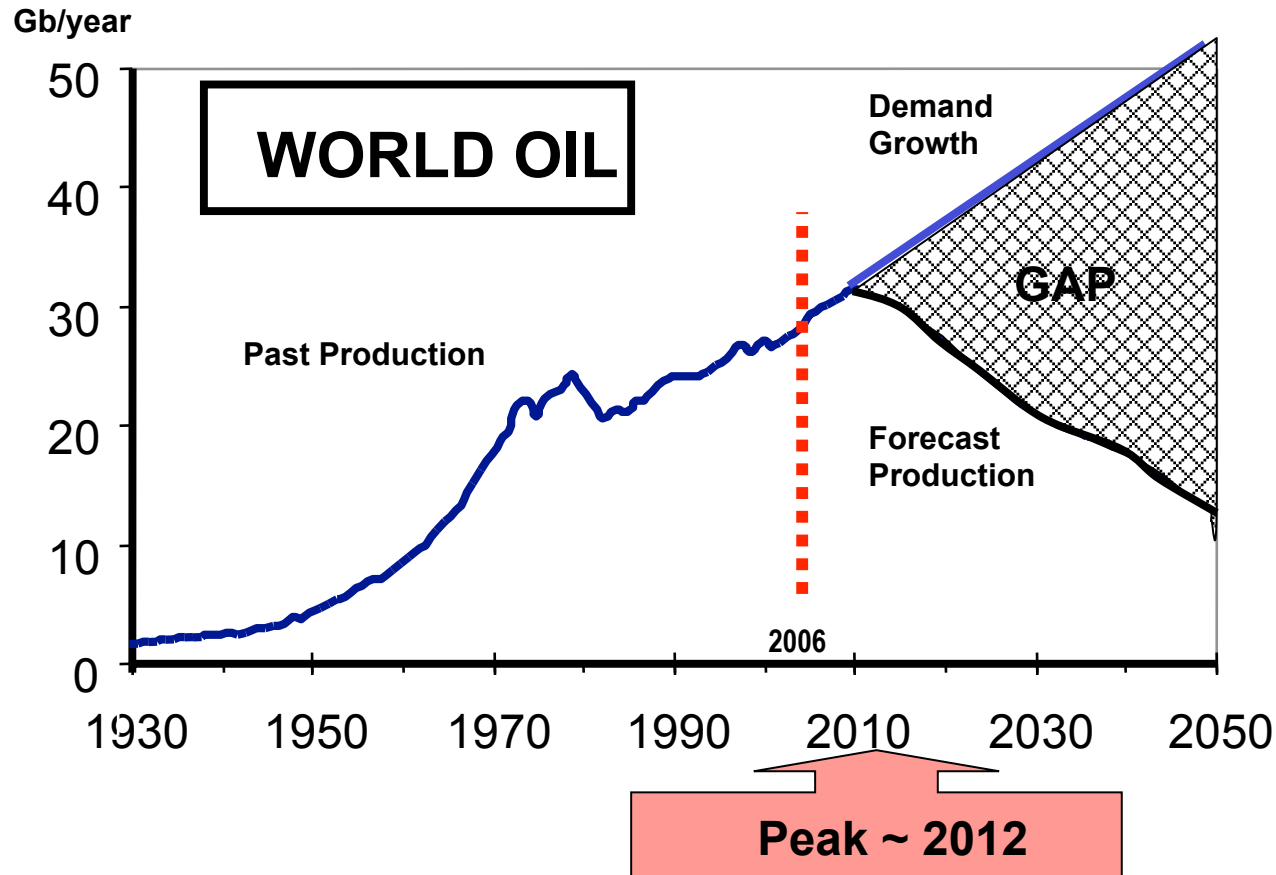


PEAK PRODUCTION CAN BE SUDDEN & SHARP



Will the world behave like this?

A CHINESE VIEW OF PEAK OIL



China aggressively securing oil supplies worldwide

2. OIL SHORTAGES WRONGLY PREDICTED FOR 100 YEARS – NO NEED TO WORRY NOW

- **Wrong**
- “Oil shortages” predicted for past 100 years, and repeated erroneous predictions may have given false assurance and led to discounting recent predictions
- Most past peaking predictions were wrong.
 - Hubbert was right on the U.S. Lower 48
 - Recent predictions may be right -- **Wrong isn't forever**
- Many countries have past peak production & are now in decline
- **Why reconsider peaking now?**
 - World oil consumption outstripping new discoveries
 - CAPEX for new energy projects is large and growing
 - Extensive drilling worldwide - large database
 - Advanced technology: Modern geology, 3D seismic, etc.
 - Many experts are pessimistic
 - The **economic consequences are huge**

WHEN MIGHT PEAKING OCCUR?

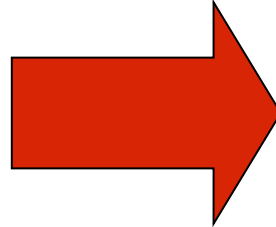
Different Approximations Lead to Different Forecasts

<u>Forecast</u>	<u>Source</u>	
December 2005	Deffeyes (U.S.)	Already
2006-2007	Bakhitari (Iran)	
2006-2007	Simmons (U.S.)	5 years
2010 +/-	Skrebowski (U.K.)	
2010	Campbell (Ireland)	
Before 2010	Goodstein (U.S.)	
After 2010	World Energy Council	5-15 years
2012	Weng (China)	
2016	Doug-Westwood (U.K.)	
After 2020	CERA (U.S.)	
2030 or later	EIA (U.S.) / Exxon Mobil	> 20 years

PEAKING FORECAST RELATIVELY INSENSITIVE TO RESOURCE ESTIMATES

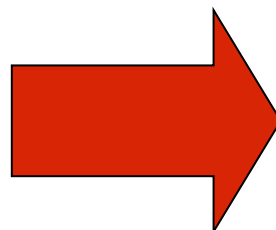
Already consumed worldwide: ~ One Trillion Barrels

Some estimates of remaining world reserves = One Trillion Barrels



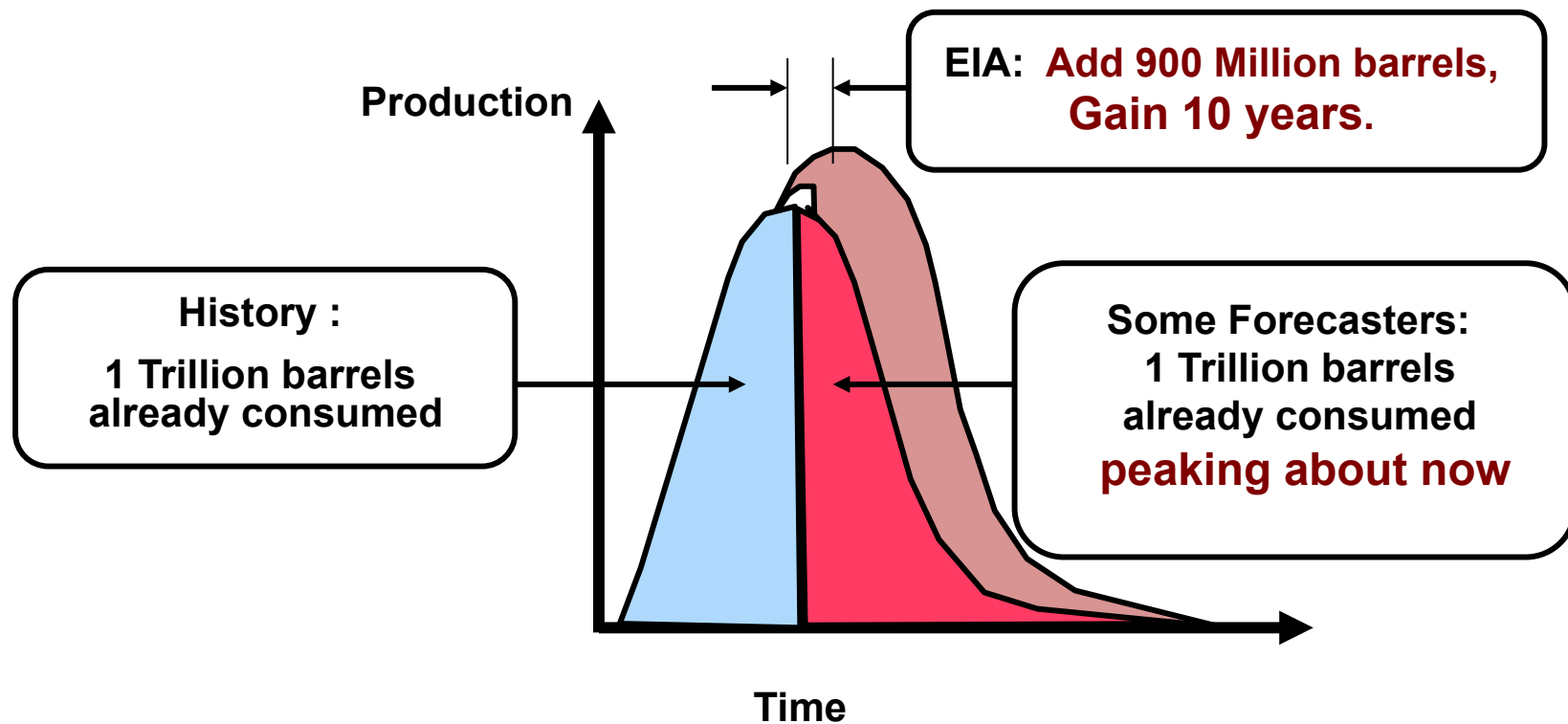
If so, world oil peaking is about now.
[50% of total]

Others estimate remaining world reserves = Two Trillion Barrels



EIA: “(Our) results are remarkably insensitive to ... alternative resource base estimates... adding 900 Bbbl more oil ... only delays the estimated production peak by 10 years.”

ADDING ALMOST A TRILLION BARRELS GAINS ONLY 10 YEARS

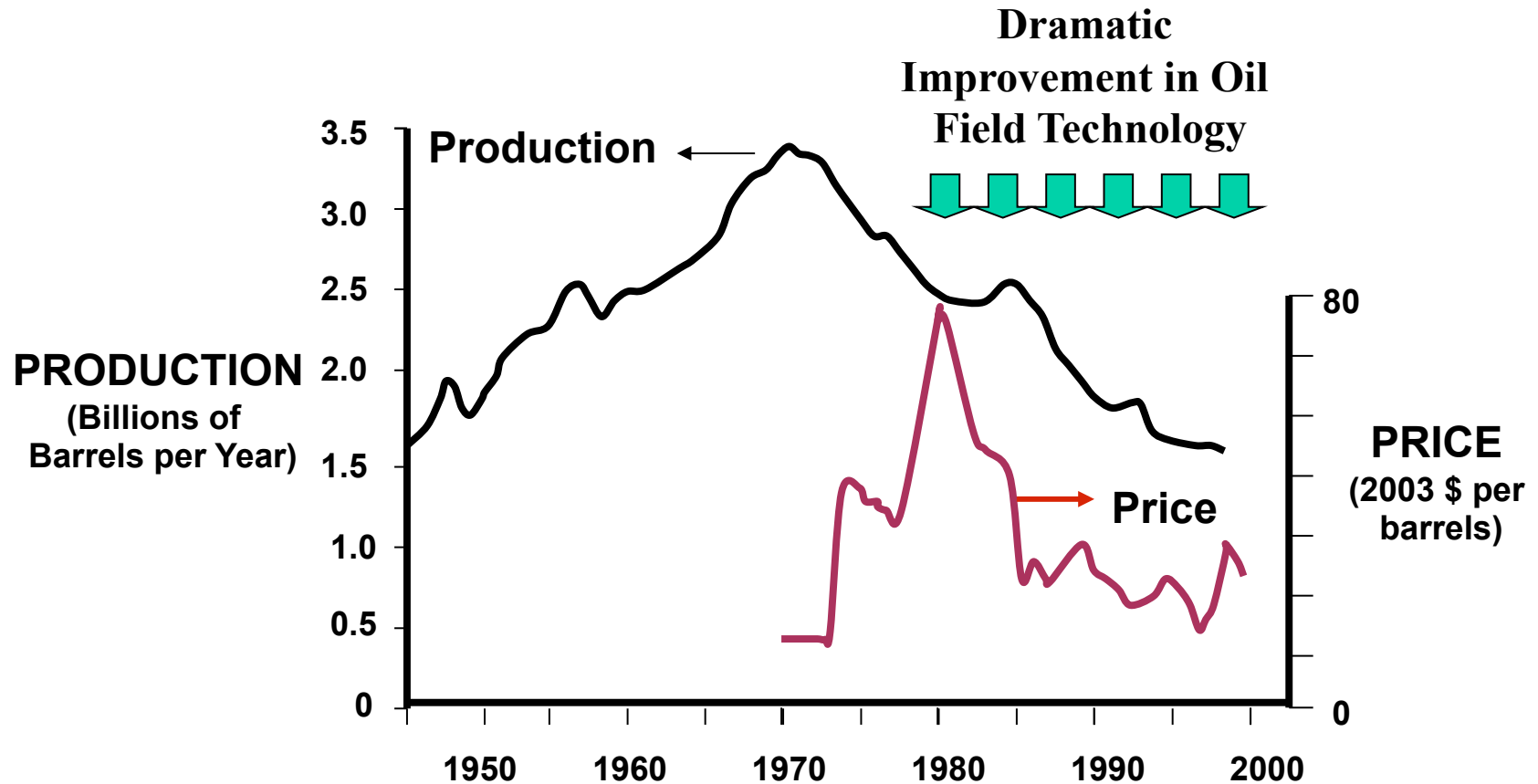


3. HIGHER PRICES WILL CREATE MORE OIL?

- **Not true**
- “Economists are better at finding oil on paper than geologists are at finding it in the ground”
- **Oil is found in discrete packages** (reservoirs), as opposed to the varying concentrations characteristic of many minerals.
- Thus, at some price, world reserves of recoverable conventional oil will reach a maximum because of geological fundamentals.
- Beyond that point, insufficient additional conventional oil will be recoverable at any realistic price.
- **This is a geological fact often misunderstood** by people accustomed to dealing with hard minerals, whose geology is fundamentally different.
- Norway, UK, other oil producing nations have peaked within past several years with very high oil prices.
- Indonesia, a long standing OPEC member, is now a net oil importer.

TECHNOLOGY & PRICE MAY NOT SAVE US

U. S. Lower 48 Oil Production

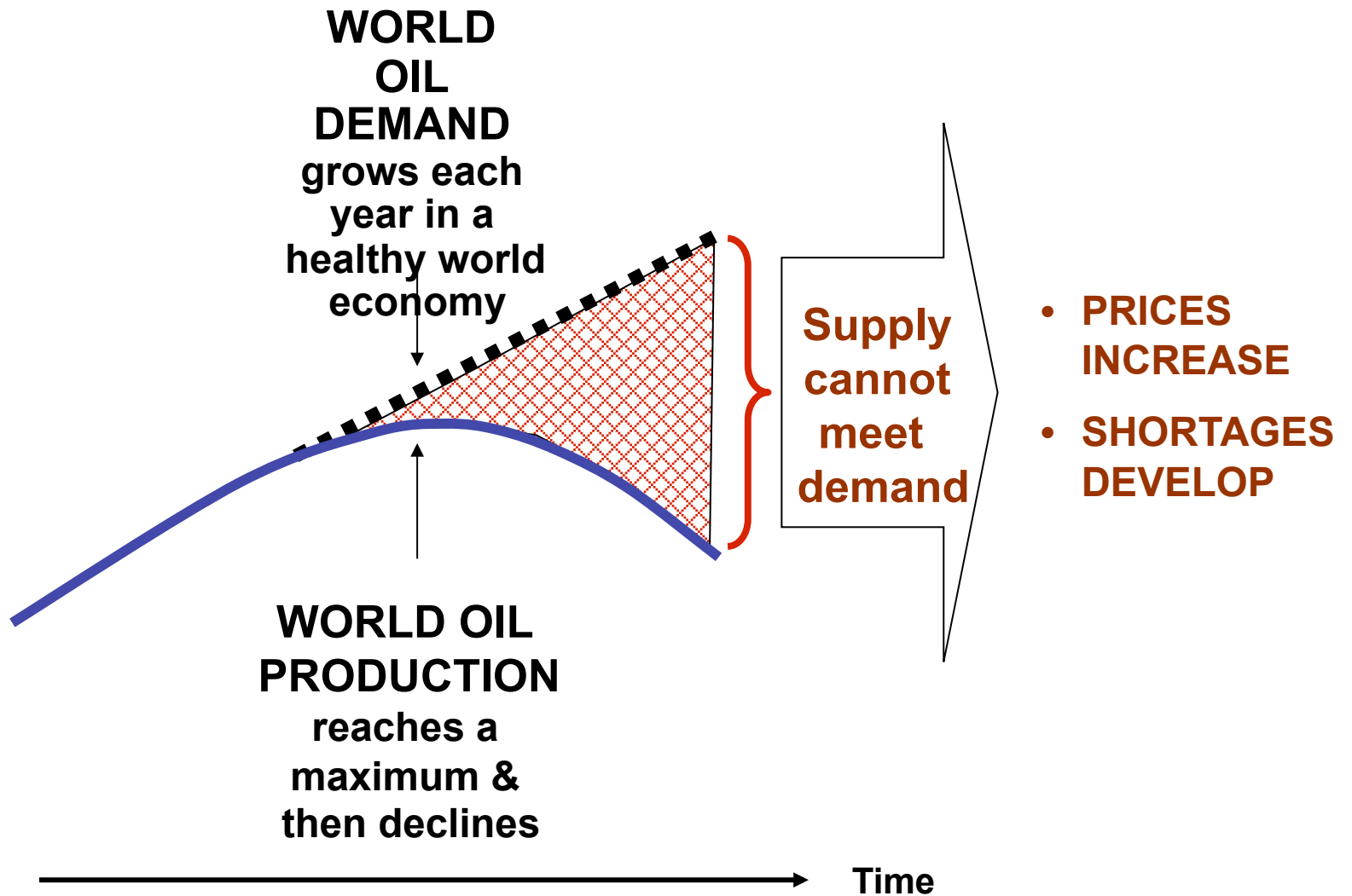


Trends were not reversed, and continued decline is forecast

4. NOT TO WORRY, WORLD WILL MUDDLE THROUGH?

- **Not true**
- We should be very worried.
- The problem of the peaking of world conventional oil production is unlike any yet faced by modern industrial society.
- Previous energy transitions, from wood to coal and from coal to oil, were gradual and evolutionary.
- World may be facing an imminent energy discontinuity that will be abrupt and painful.
- World has yet to grasp this or its implications.

WHAT MIGHT HAPPEN AT PEAKING?

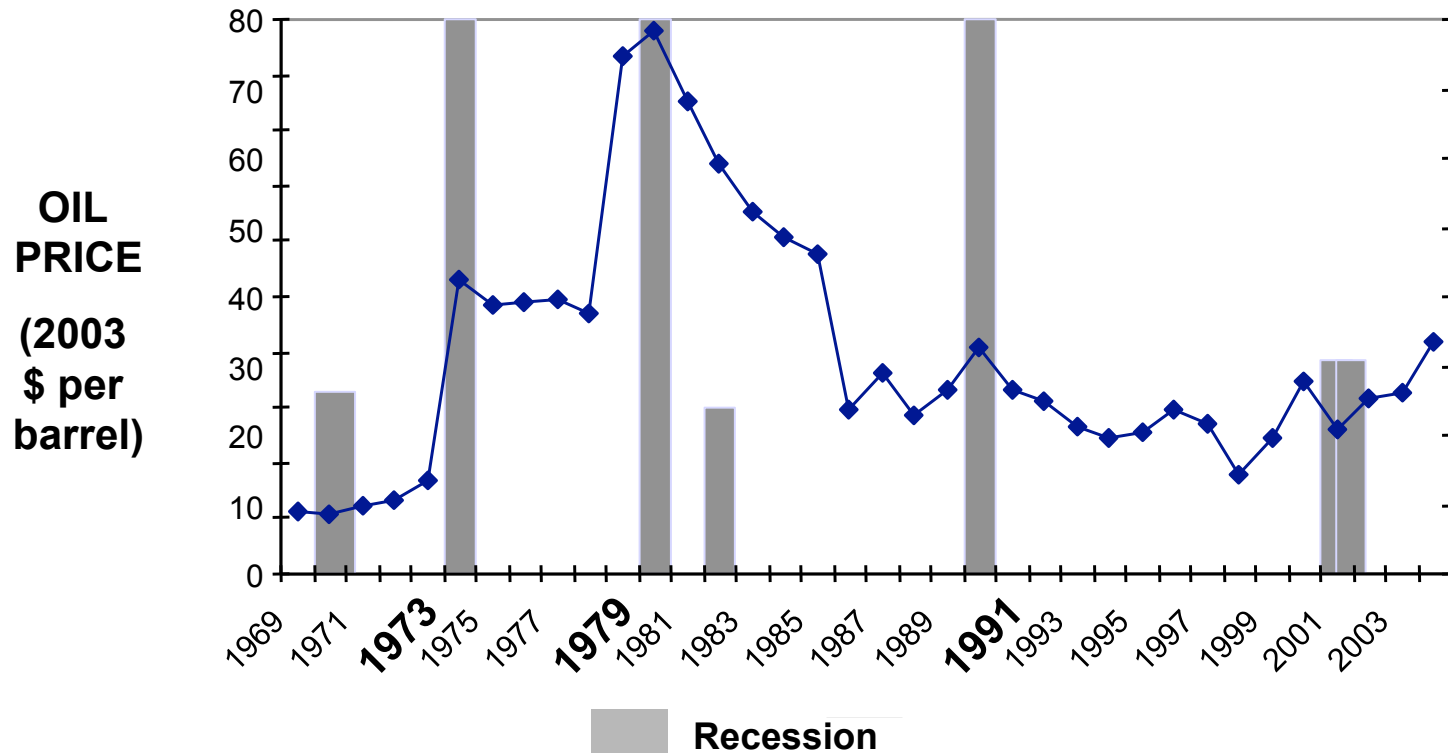


REMEMBER THE 1970S? STAGFLATION, RECESSION

-- That was only a short-term disruption

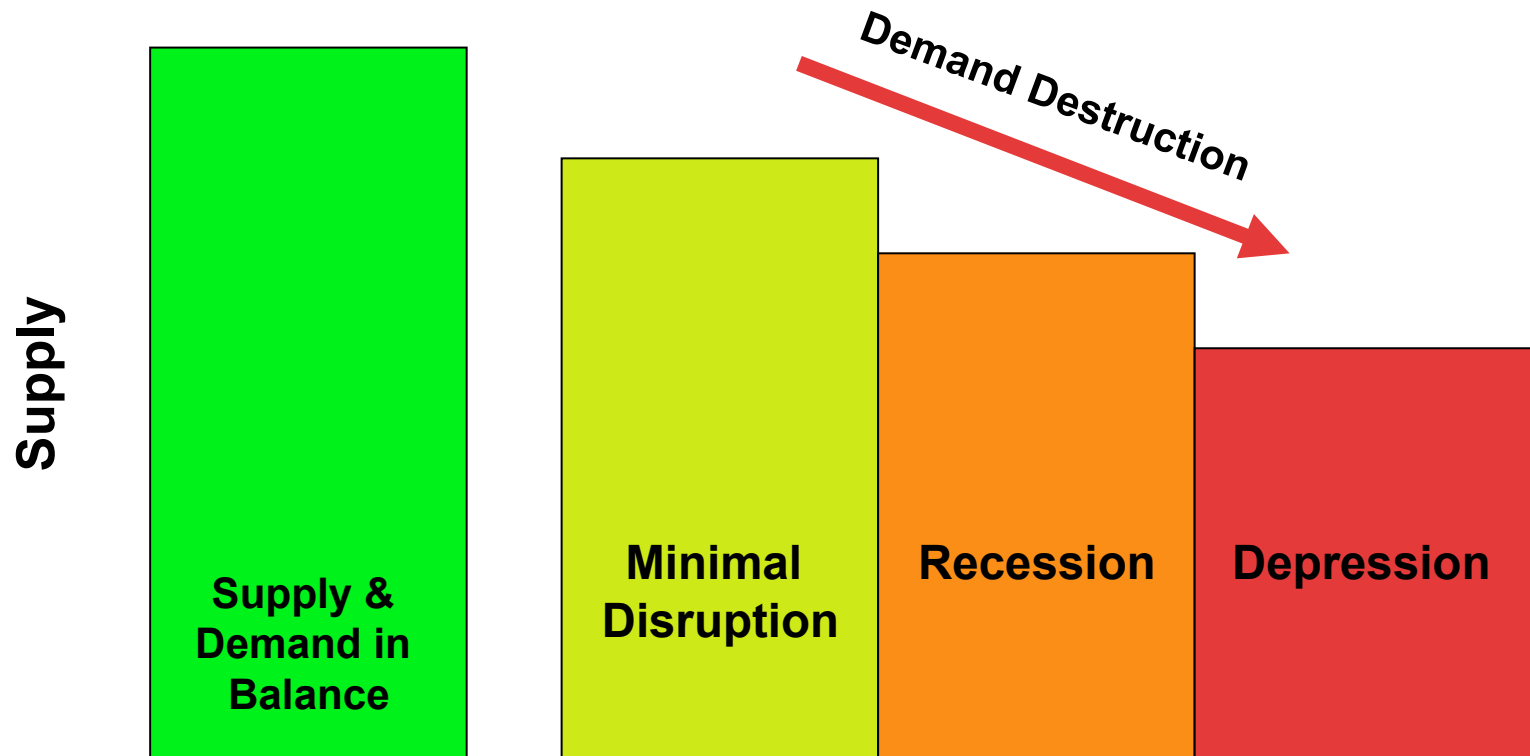


OIL PRICE INCREASES HAVE CAUSED U.S. RECESSIONS



Over 30 years, four recessions followed oil price spikes.

GROWING OIL SHORTAGES WILL INDUCE GROWING WORLD “DEMAND DESTRUCTION”



WHAT ABOUT “DEMAND DESTRUCTION”

- **Is demand destruction the solution or the problem?**
- It is always the “default solution:” Absent mitigation initiatives, it will always equate oil supply with demand
- However, **demand destruction is an euphemism for recession, depression, mass unemployment, etc.**
- People – & governments – will not passively accept massive demand destruction and may opt for desperate alternatives
- Therefore, **objective is to use mitigation initiatives to minimize and control demand destruction**

5. JUST ANOTHER “ENERGY CRISIS”?

- **Not true**
- Not just another “energy crisis”
- Oil is the lifeblood of the world.
- Oil peaking will create a severe liquid fuels problem for the transportation sector.
- It is not an “energy crisis” in the usual sense that term has been used.
- For some forms of transportation (e.g., airplanes, heavy trucks) there is no substitute for petroleum.
- There will be no quick fixes for this problem, on either the demand side or the supply side.
- **Many analysts and policy-makers do not comprehend this.**



No, we're facing a liquid fuels crisis

WHY SO LONG TO MITIGATE?

- Energy is inherently very large scale.
 - It's not computers or electronics
 - No magic bullets
- Long time to build capacity & savings
- Long lifetimes
- Inherently expensive

The only solution: Start Early!

CHARACTERISTICS OF U.S. TRANSPORTATION FLEETS

Fleet Replace	Size	Lifetime (Years)	Median Cost to Half the Fleet (2006 \$)
Automobiles	140 million	17	\$1.6 trillion
Light Trucks, SUVs, etc.	90 million	16	\$1.3 trillion
Heavy Trucks, Buses, etc.	7.5 million	28	\$1.7 trillion
Aircraft	8,500	22	\$0.3 trillion

TRANSPORTATION EQUIPMENT CHANGES

Efficiency improvements possible:

Large in some fleets, smaller in others,

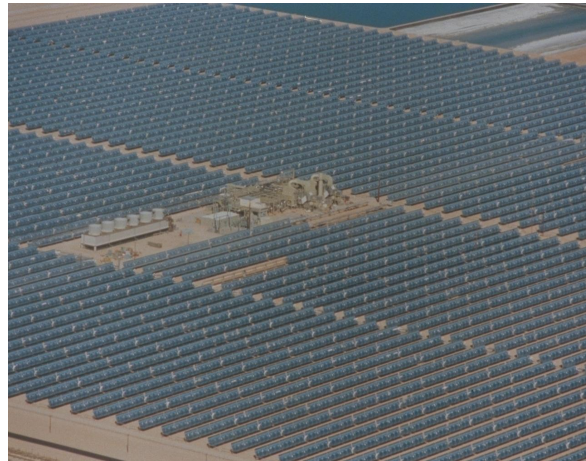
BUT

Change is slow & expensive.

Fuel must be provided for existing fleets.

6. RENEWABLES WILL SAVE US?

- **Not necessarily.**
- Major renewables do not produce liquid transportation fuels
- Only major renewable options are hydro, biomass, and geothermal, and these are site and capacity limited
- Combined they provided 5.4% of U.S. energy in 2005, and EIA forecasts that they will provide 6% in 2030
- **The most publicized renewable options – wind, photovoltaics, and solar thermal – remain niche applications:** They provided 0.15% of U.S. energy in 2005, and EIA forecasts that they will provide 0.4% in 2030
- **Only renewables capable of producing liquid fuels are biofuels**



WHAT IS RENEWABLE ENERGY?

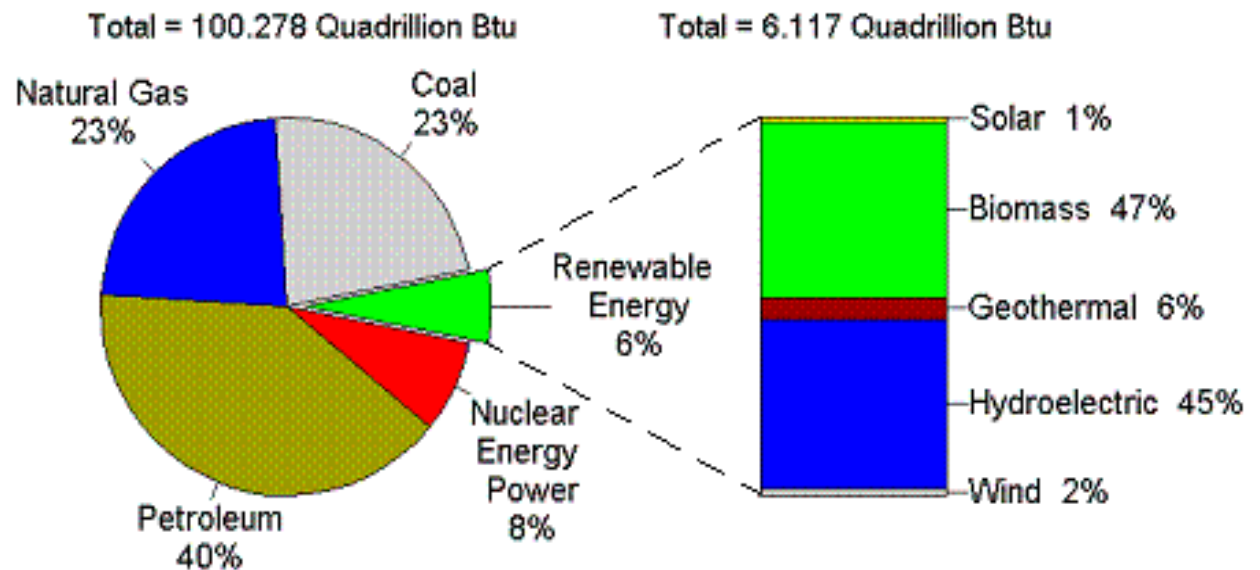
Renewable energy electricity technologies consist of:

- Hydroelectricity
- Biomass
- Geothermal
- Wind
- Photovoltaics
- Solar thermal

Except for hydro and industry biomass, **renewables' U.S.**

energy contribution is small and is forecast to remain so

Only renewable technologies such as ethanol, bio-diesel, and biomass-to-liquids, produce liquid fuels, not electricity



CELLULOSIC ETHANOL IS REQUIRED

Potential of corn-based ethanol and biodiesel is limited, and they are not energy efficient

Cellulosic ethanol (CE) is the holy grail of biomass liquids: If it cannot be made to be commercially viable, then biomass can never play a significant role in liquid fuels

Cellulosic ethanol is an alternative fuel made from a wide variety of non-food plant materials (or feedstocks), including agricultural wastes, industrial plant waste, and energy crops (like switchgrass)

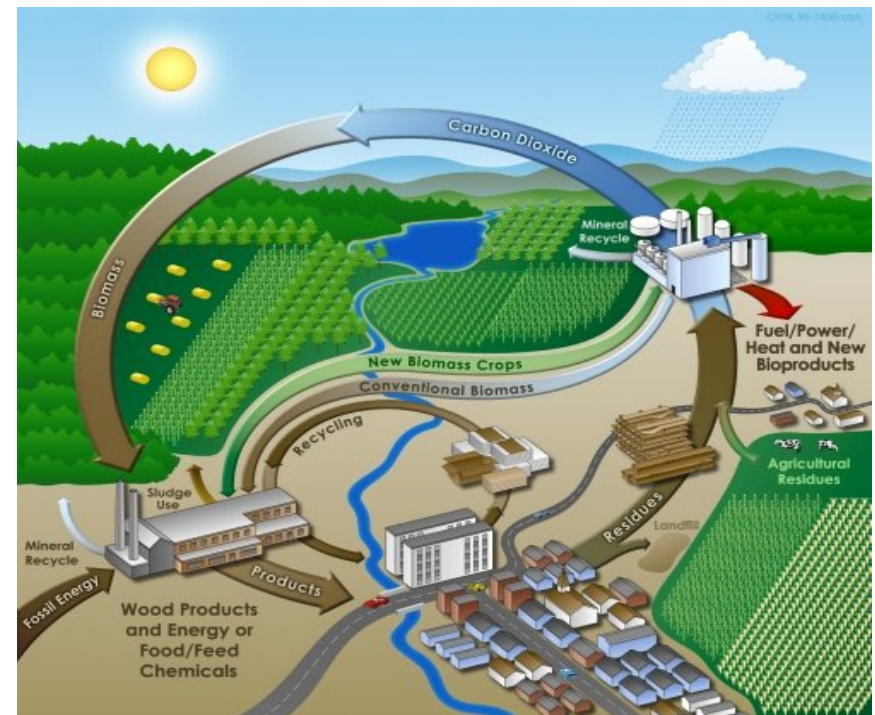
Cellulosic ethanol *must* work because other forms of ethanol are limited

Cellulosic ethanol requires a more complex, difficult, & expensive conversion process than traditional corn-based ethanol



WHAT IS EROEI OF CELLULOSIC ETHANOL?

- **EROEI is energy return on energy invested; e.g., what is the “net energy” benefit of an energy option**
- Oil has EROEI of 8-15, coal liquefaction 3-5, oil sands 2-4, oil shale 2-4, etc.
- If EROEI is < 1 , more energy is consumed than is produced and net energy output is negative
- **Studies published in scientific journals** indicate that the **results for CE are mixed, but are near 1**
- Thus, it is still very much an **open question as to whether or not cellulosic ethanol has a net positive energy benefit**



BASIC FACT: IT TAKES ENERGY TO MAKE ENERGY

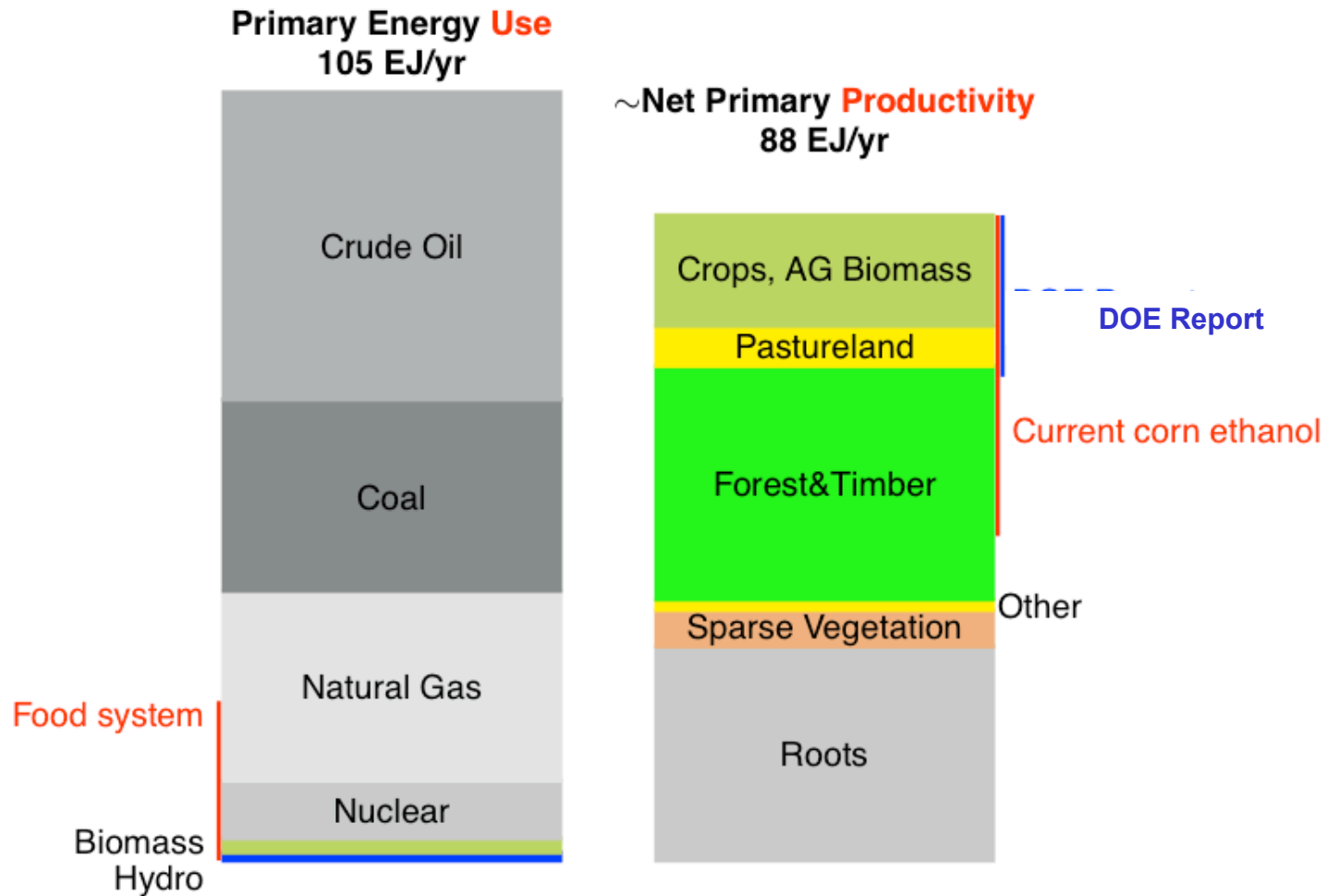
(All fuel conversion processes lose energy)

<u>Process</u>	<u>Conversion Type</u>	<u>Efficiency</u>
Dry Cell Battery 85-95%	Chemical to Electrical	
Natural Gas to Compressed	Chemical to Chemical	85%
Crude Oil to Gasoline	Chemical to Chemical	79%
Natural Gas to H ₂	Chemical to Chemical	60%
Coal to Gasoline	Chemical to Chemical	50%
Grid Electric to H ₂	Chemical to Chemical	22%
Photovoltaic	Radiative to Electrical	15-25%
Soybean to Bio-Diesel 30%	Chemical to Chemical	
Corn to Ethanol	Chemical to Chemical	5-10%
Plant Photosynthesis	Radiative to Chemical	4-5%

BIOMASS FEEDSTOCK PRODUCTION IS VERY FOSSIL FUEL INTENSIVE



CURRENT U.S. ENERGY CONSUMPTION IS 20% GREATER THAN ALL U.S. BIOMASS



CELLULOSIC ETHANOL PLANT FACT OF LIFE

After 50 years and >\$1 billion of R&D, only one pilot plant (logen Corp.) is operating, producing about 160,000 gal./yr. of ethanol -- 1/6 of its planned capacity, with lack of scalability

In addition to cutting most vegetation in U.S., to obtain 130 billion gal. of ethanol by 2030 **logen plant must be scaled up 81,000 times**

In human history, **such scale up has never occurred** within 20 years

We would need 67,000 logen Ottawa plants just to replace the petroleum refineries in Texas alone

Industrial cellulosic ethanol technology does not exist

Bottom line: Dangerous to assume that cellulosic ethanol will make major contribution to liquid fuels needs



7. GOVERNMENT INTERVENTION NOT REQUIRED?

- **Wrong: Intervention by governments will be required**
- Economic and social implications of oil peaking would otherwise be chaotic
- The **experiences of the 1970s and 1980s offer important guides** as to government actions that are desirable and those that are undesirable
- Process will not be easy
- Burden of mitigation will fall on industry
- However, due to the need for urgent action, governments will have to provide support, incentives, and facilitation
- But **government intervention can have both positive and negative effects**

GOVERNMENT ACTIONS: DESIRABLE AND UNDESIRABLE

- **The past can be a guide to the future**
- **Worthwhile government initiatives**
 - Mandated energy efficiency programs
 - R&D
 - Scientific and technical education and training programs
 - Demonstration and pilot plants
 - Guaranteed price floors for alternative fuels
 - Provision of objective information and analyses
 - International burden sharing agreements
 - Development of strategic energy reserves
 - Data gathering – especially reliable oil & gas reserve data
 - Rational tax policies
 - Vehicle fuel efficiency standards
 - Targeted, market neutral subsidies and incentives
 - Public education as to the problems we face

GOVERNMENT ACTIONS: DESIRABLE AND UNDESIRABLE

- **Questionable government initiatives**
 - Bashing the energy companies – may be popular, but national oil companies control 80 – 90% of world oil
 - Gasoline rationing – nightmare no matter how implemented
 - Price controls – lead to shortages and black market
 - Allocation controls – impossible to enforce
 - “Excess profits” taxes
 - Picking “winners and losers”
 - Subsidies and incentives that are not market neutral
 - Spurious regulations; e.g., speed limits, odd-even fuel availability days, micro fuel restrictions, etc.
- **Government intervention that is highly unpopular with public will ultimately not be effective** – U.S. examples: alcohol prohibition during 1920s; energy controls during 1970s

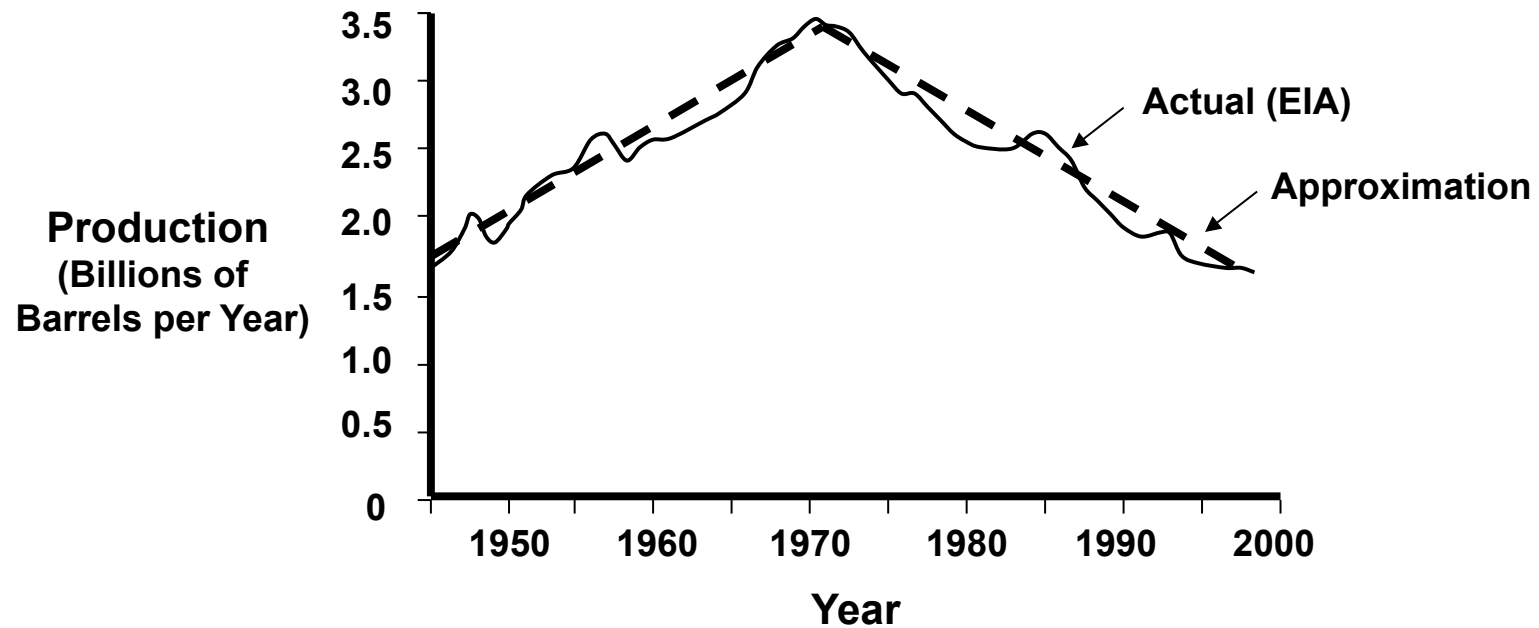
SOME ISSUES GOVERNMENTS MUST ADDRESS

- Skilled workers & industrial capacity worldwide are in short supply for the level of effort that is required
- Massive commercial crash programs are rare
- Startup will almost certainly be much slower (and cost more) than is generally assumed
- Some countries may delay, others will proceed rapidly with mitigation. China may have started (Canada, Venezuela)
- Not clear how environmental protection will fare if there is widespread joblessness, high inflation, & severe recession
- Relationship between peak oil and climate change – two intractable long term problems the world faces

8. PLENTY OF TIME TO ADDRESS THE PROBLEM?

- **Not true**
- **Time may have already run out to avoid serious problems.**
- Waiting until conventional oil production peaks before initiating crash program mitigation leaves world with a significant liquid fuel shortage for two decades or longer.
- **Viable mitigation options exist.**
- However, they must be implemented on a crash basis at least a decade or more in advance of oil peaking.
- Thus, if oil peaking occurs within the next decade (as many experts predict), it may already be too late to avoid severe worldwide economic and social consequences.
- **Action is required immediately.**

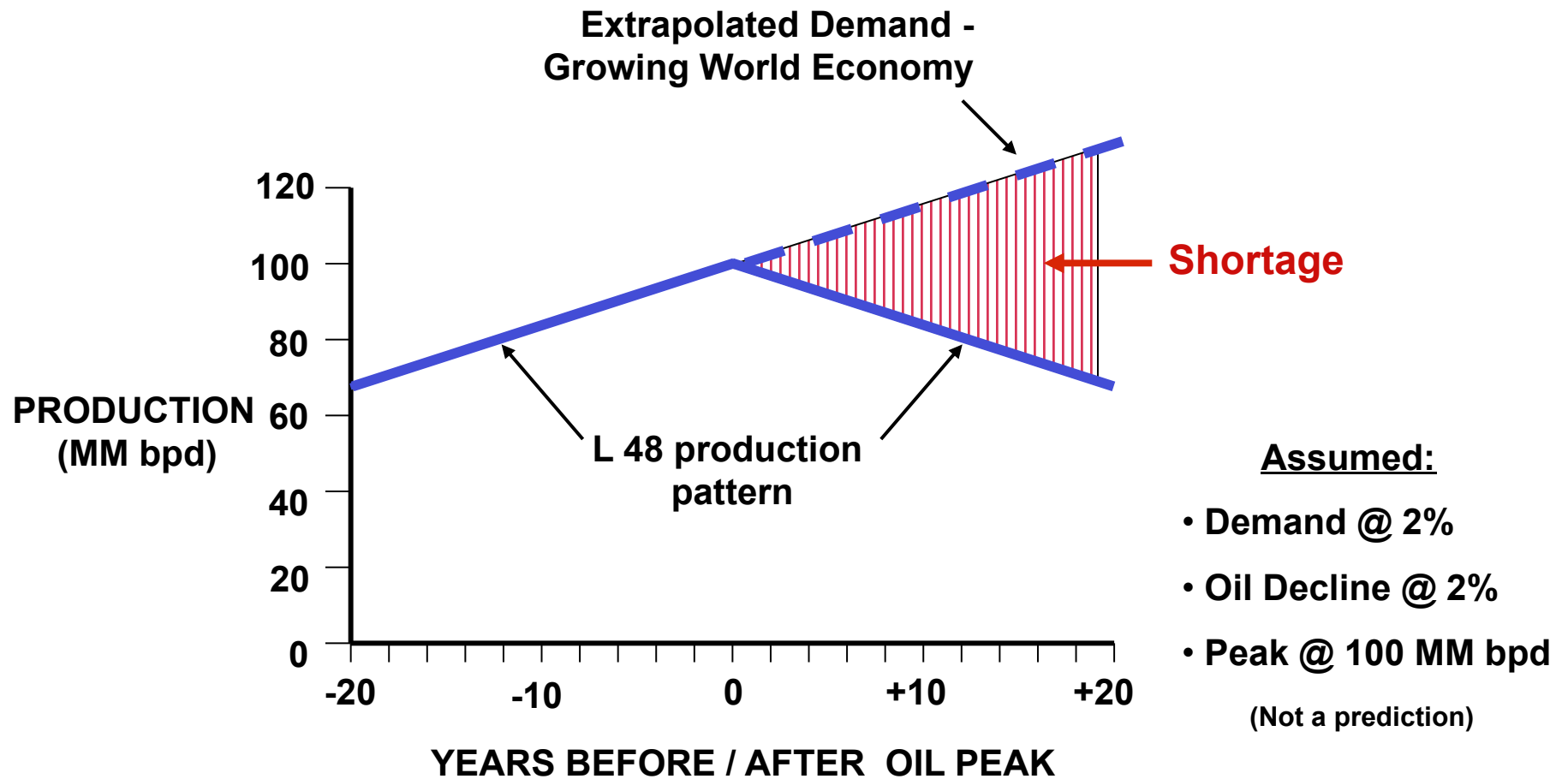
U.S. LOWER-48 OIL PRODUCTION PEAKED & DECLINED



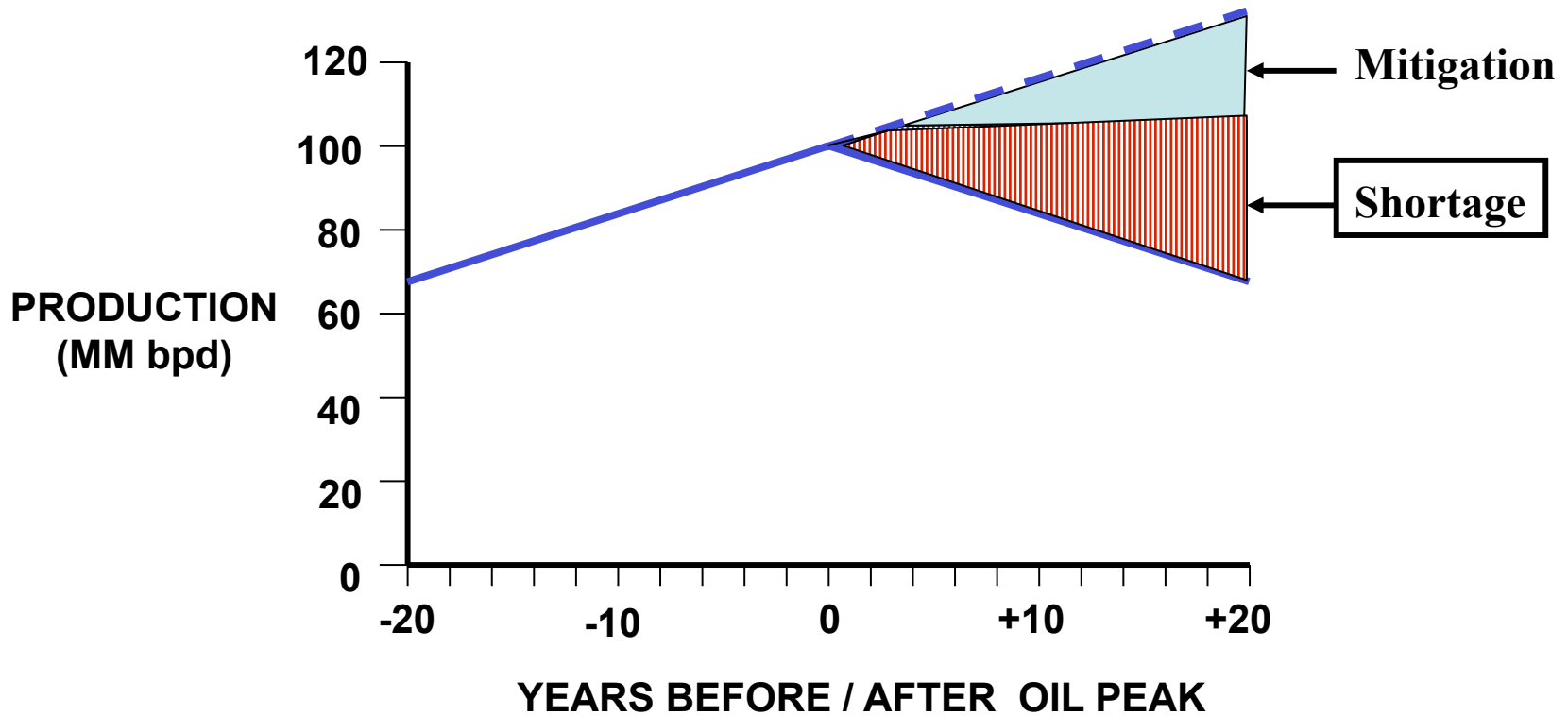
**A huge, complex & geologically varied oil province.
We used this pattern as a surrogate for the world.**

WORLD OIL SUPPLY & DEMAND

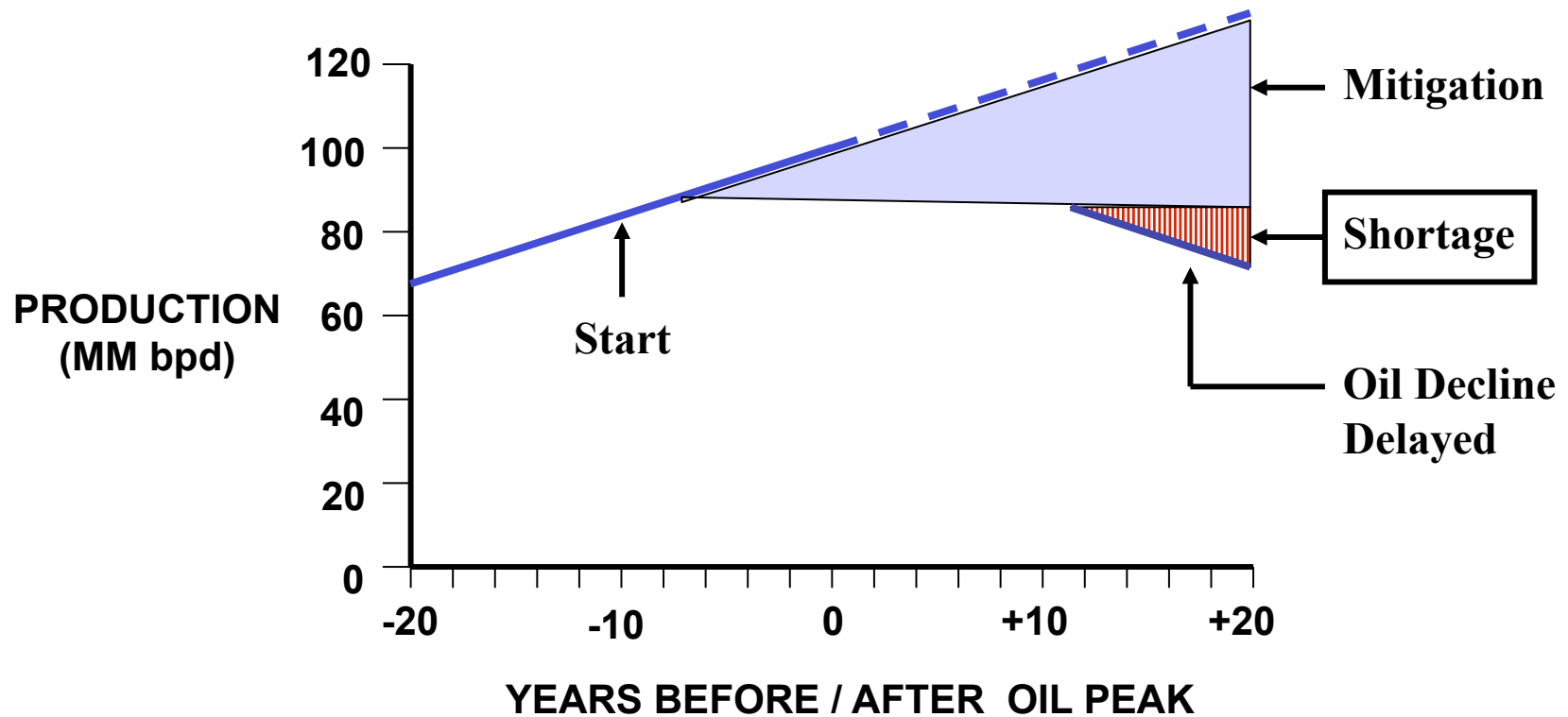
LOWER 48 PRODUCTION PATTERN & EXTRAPOLATED DEMAND GROWTH



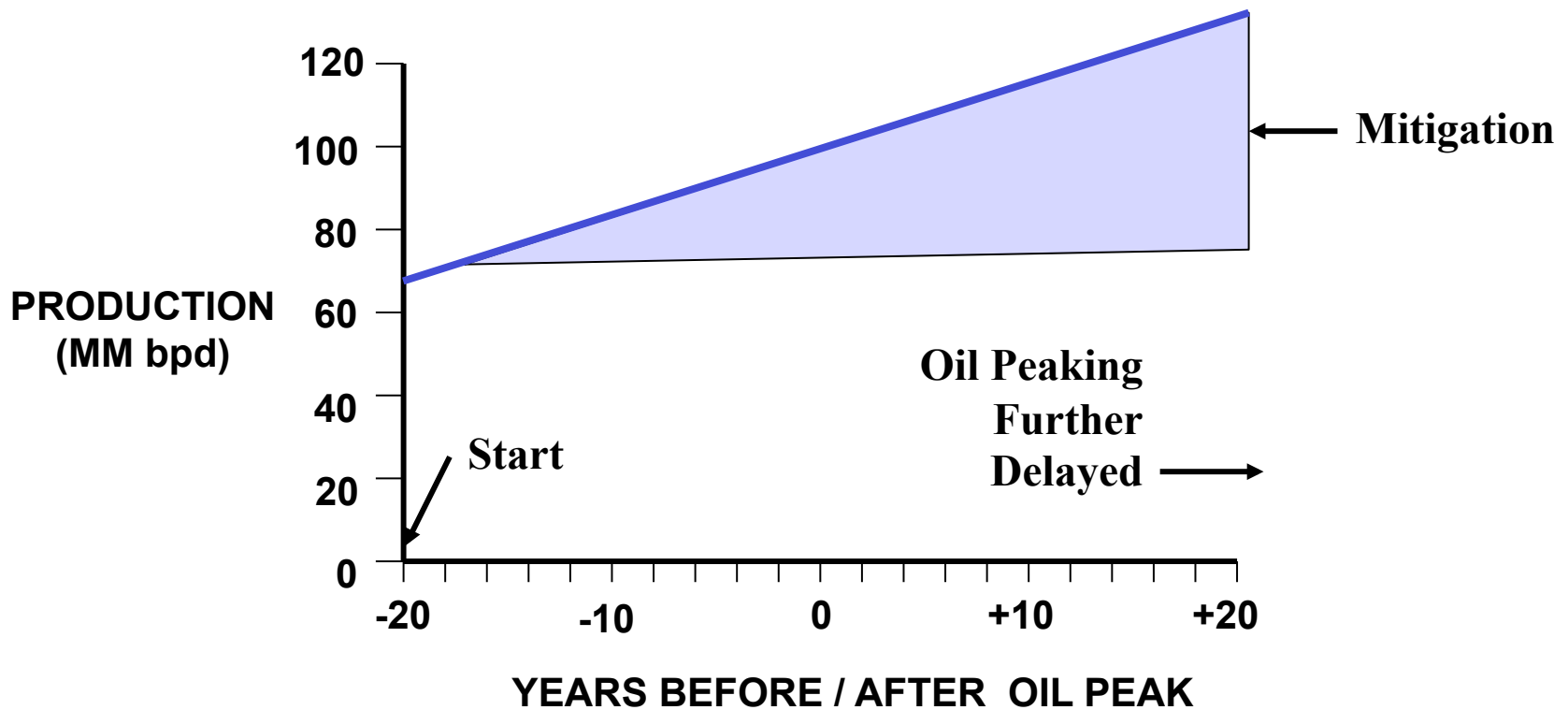
SCENARIO I: MITIGATION @ PEAKING



SCENARIO II: MITIGATION 10 YEARS BEFORE PEAKING BEFORE PEAKING



SCENARIO III: MITIGATION 20 YEARS BEFORE PEAKING BEFORE PEAKING



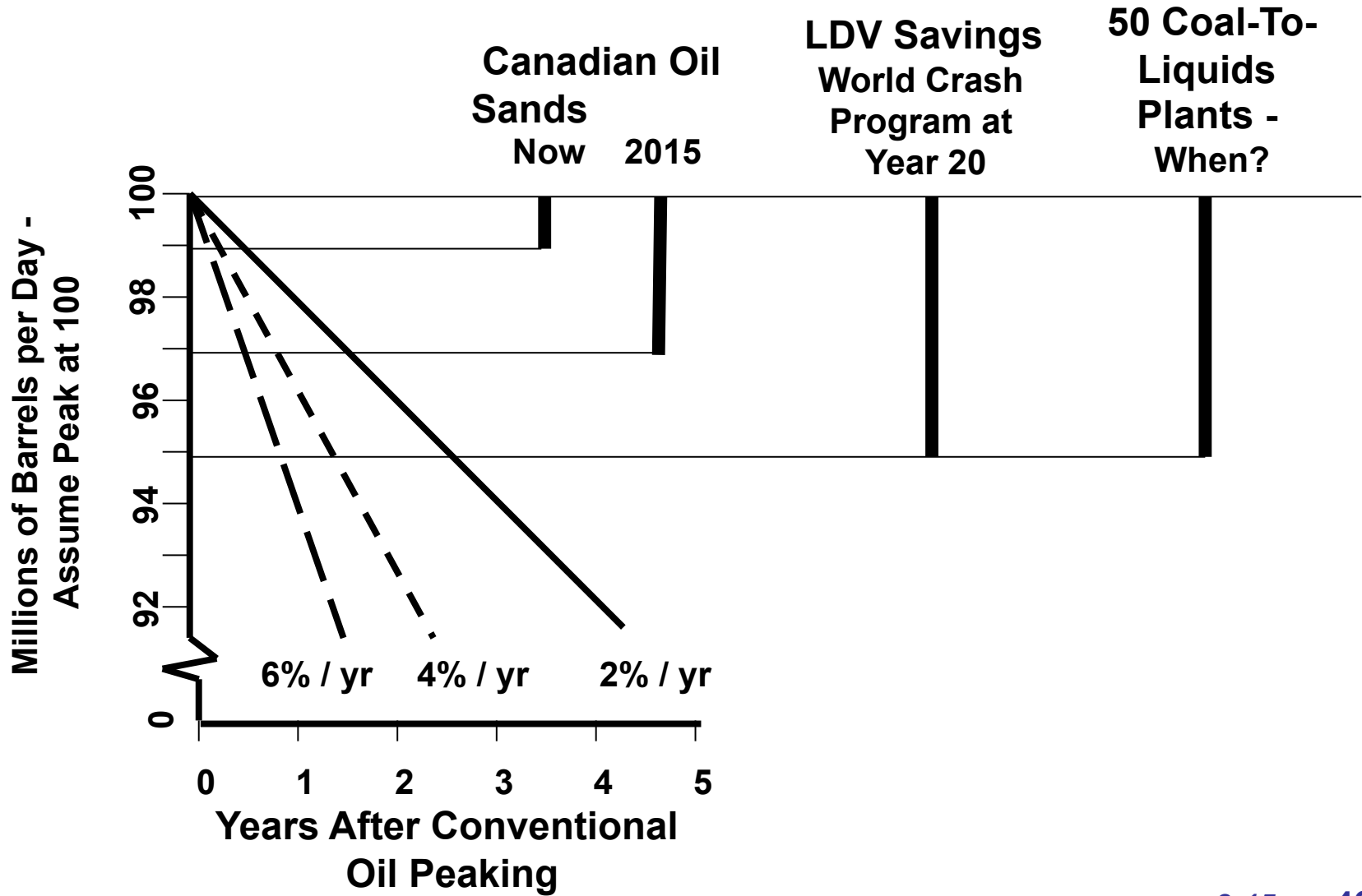
SCENARIOS ANALYSIS CONCLUSIONS

Basis: Immediate crash program implementation

Scenario	Result
Wait for peaking	Oil shortages largest, longest lasting
Start 10 years early	Delays peaking; still shortages
Start 20 years early	Avoids the problem; smooth transition

No quick fix!

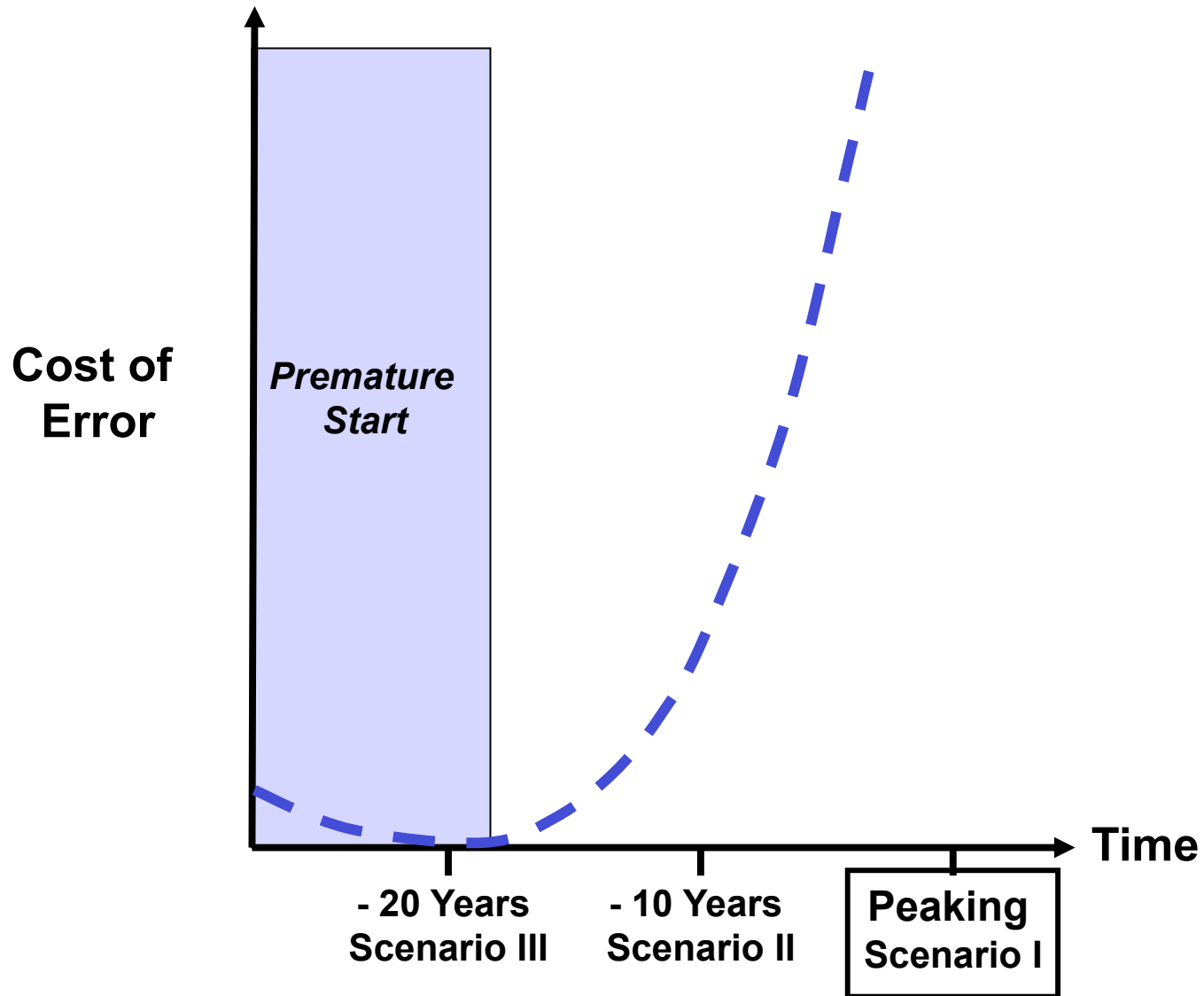
SOME MITIGATION EXAMPLES



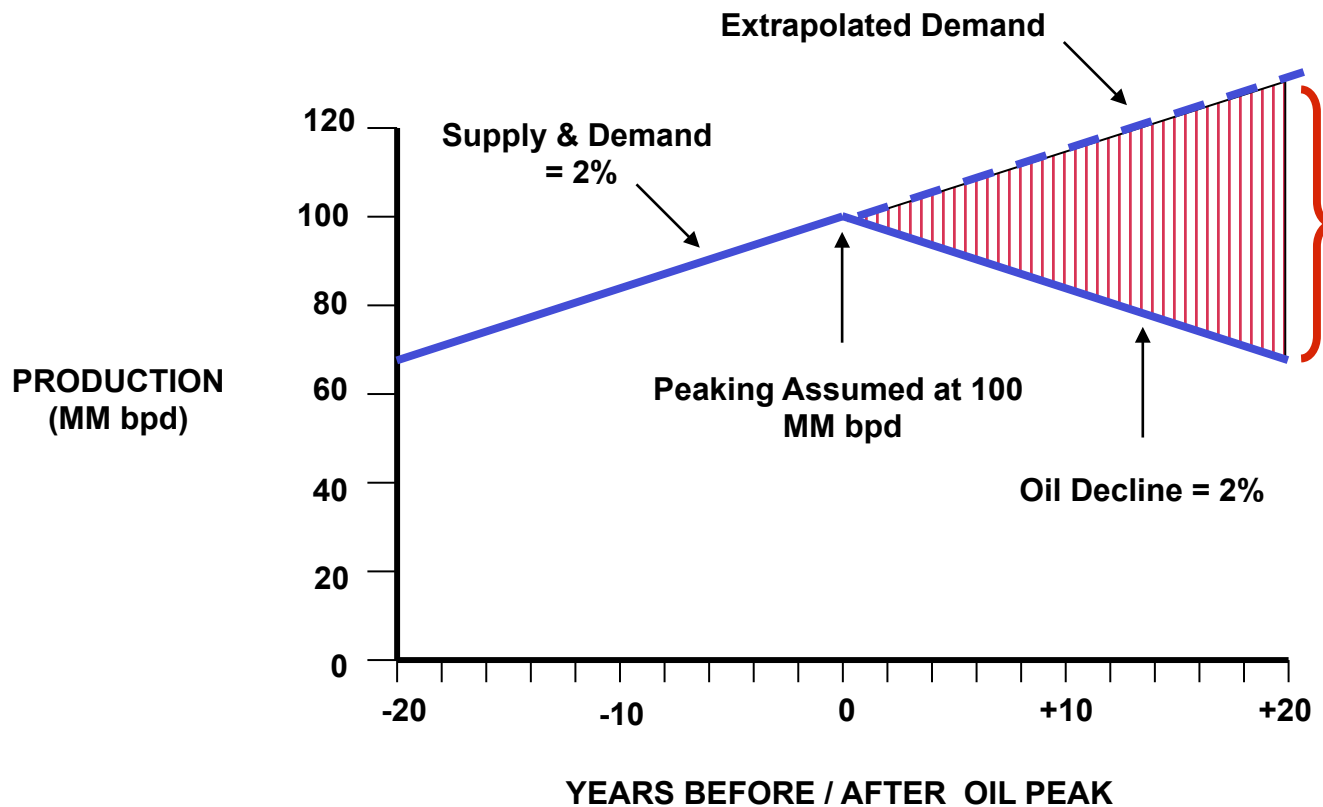
9. OIL PEAKING MEANS “END OF CIVILIZATION AS WE KNOW IT”

- **Not true**
- Recent spate of doomsday books and apocalyptic scenarios:
 - “Back to the earth”
 - Abandon the cities
 - Abandon the suburbs
 - Reduce world population by 90%
 - Economic and financial collapse
 - War, famine, disintegration of civil order, etc. -- “Mad Max” on steroids
- However, **viable risk management and mitigation options exist** on both the supply and demand sides
- But to have substantial impact, they must be initiated more than a decade in advance of peaking
- **To avoid adverse effects, we must start now – or yesterday**

COST AS A FUNCTION OF START TIME (Notional)



LOOK AGAIN AT THE SHORTFALL



**The
“shortage”
after 20 years
could be 80%
of today’s
world oil
consumption**

65 / 82 ~ 80%

IMPLICATIONS OF FINDINGS

Controversy over interpretation; **findings have various implications:**

- Costs and benefits of liquid fuel requirements
- What is required to maintain “current energy regime”
- Implications of maintaining “current energy regime”
- What is required to change “current energy regime”
- **What is the “new energy regime”**
- Time & \$ required to transition to “new energy regime”

How to get from “here” to “there” – new energy regime
What is “there”? When is there: 2020? 2030? 2050?

Major finding: Problem is of enormous scale, will require decades to resolve, and will require \$ trillions investment.
No easy, “painless” solution

IMPLICATIONS FOR SUPPLY CHAIN MANAGEMENT

- Major disruptions will impact virtually all aspects of the supply chain
- The industry can expect considerable instability in a number of areas.
- Transportation is especially vulnerable.
- Planning will become much more difficult and as disruptions occur and uncertainty increases.
- Prices will become far more volatile.
- Risks will also increase as managers have less control over major portions of the supply chain.
- In midst of such an unfamiliar global situation, preparation and planning are crucial.
- **Major implication:** Increased risk and uncertainty throughout the supply chain

RECOMMENDATIONS FOR SUPPLY CHAIN MANAGEMENT

- **Two major ways that the supply chain industry can prepare for world oil peaking.**
- **In micro sense**, supply chain managers have to recognize what is likely to happen in the future and change their plans and methods of doing business accordingly.
 - Educate themselves as to the reality and implications of looming oil shortages
 - Shifting to more efficient and secure models of transportation and inventory management
- **In a macro sense**, all participants in the supply chain should encourage their national and regional governments to recognize the impending liquid fuels crisis and take appropriate remedial actions.
- **Burden of mitigation will fall on industry**, but governments must provide support, incentives and facilitation to ensure action is taken.

THE EXAMPLE OF FED EX

- **A major player in supply chain business**
- \$32 billion in revenues, 250,000 employees, >700 aircraft, 50,000 vehicles
- In 2006, spent \$3.5 billion for fuel
- **FedEx actions, micro:**
 - Abandoned fuel price hedging; utilizing fuel surcharges
 - Seeking more fuel efficient and hybrid vehicles
 - Exploring use of alternative aviation fuels
- **FedEx actions, macro:**
 - Co chair Securing America's Future Energy, dedicated to reducing U.S. imports and increasing energy security
 - Encouraging Federal govt. development of alternate fuels
 - Promoting U.S vehicle fuel efficiency standards



THREE POLICY RECOMMENDATIONS

- 1. Federal government** should increase vehicle fuel efficiency standards and initiate substitute liquid fuels mitigation options.
 - On the demand side, government should stress transportation efficiency and enhanced fuel efficiency standards for all types of vehicles.
 - On the supply side, government should encourage and pursue all viable options: Coal-to-liquids, oil shale, oil sands, enhanced oil recovery, heavy oil, gas-to-liquids, biomass, diesel, hybrids, and plug in electric vehicles.
- 2. State and local governments** should encourage smart growth, telecommuting, mass transit, and other transportation fuel efficiency options and facilitate and expedite the siting of substitute liquid fuels plants.
- 3. All levels of government** should educate the public to the fact that we face a serious liquid fuels problem that will require controversial and unpopular measures to reduce demand and increase supply.

HOWEVER, UNLESS AGGRESSIVE MITIGATION INITIATIVES ARE BEGUN SOON.....



It could happen again!

LOCAL CONTACT INFORMATION

**While in Australia through July 6,
Dr. Bezdek can be contacted via ASPO Australia**

Association for the Study of Peak Oil and Gas

International



Australia



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